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Effect of different nitrogen doses on sucking pests and yield in *Bt* cotton under unprotected and protected conditions

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Abstract
An experiment was conducted to know effect of different nitrogen doses (0, 120, 150, 180, 225, 280, 350, 440 kg ha^{-1}) on sucking pests and yield in Jaadu BG-II cotton hybrid under protected and unprotected conditions at RARS, Lam, Guntur. The mean aphid population was increased from 14.12 to 42.54 and 9.67 to 26.20 per three leaves under unprotected and protected conditions respectively. Similarly, the mean leafhopper population was increased from 3.54 to 6.52 and 2.51 to 4.99 per three leaves under unprotected and protected conditions respectively. Significant positive correlations were observed with pest population. The highest seed cotton yield was obtained from plots applied with 150 kg N ha^{-1} both under unprotected (1967 kg ha^{-1}) and protected (2272 kg ha^{-1}) conditions. However, thereafter decrease in yield was observed with increased nitrogen level.

Keywords: *Bt* cotton sucking pests, nitrogen levels, yield, unprotected and protected

1. Introduction

Cotton (*Gossypium hirsutum* L.), the "White gold" is one of the most important commercial and industrial crops and plays a key role in economical and social affairs of the world and it is considered as "King of fibres". The major factor responsible for the low productivity and quality deterioration of cotton in the state as well as in the country is the severe attack of insects / pests on cotton crop from sowing to harvesting. Adoption of *Bt* cotton has not only changed the cultivation profile, but also the pest scenario. While there is a decline in the pest status of bollworms; the sap feeders, *viz*. aphids, jassids, mirids and mealy bugs are emerging as serious pests [1]. Thus, insect pests remain a main determinant factor in sustainable cotton production. *Bt* cotton hybrids and their scope for extensive coverage in the country in coming years, necessitated for change in the nutrient management of *Bt* cotton hybrids. Fertilizer application plays an important role in raising cotton production. Nitrogen is utilized in cotton plant to greater extent and is generally considered the most important nutrient for maximizing the cotton yield. In recent years there has been tendency among cotton growers to increase maximum yield potentials by applying higher amount than that recommended nitrogen rates. *Bt* cotton at higher densities responding to higher nitrogen levels (25% more than recommended dose of N) and producing significantly higher yields [2]. The nitrogen as feeding regulator can positively or negatively affect the feeding amounts of herbivores on host-plants with high nitrogen content in two ways. Given choices, many insect herbivores can distinguish host plants of high nutritional quality from those of low quality. Highest mean population of leaf hopper, whitefly and thrips per leaf were found at plants receiving higher doses of nitrogen [3]. Higher nitrogen levels provide congenial substratum for growth and development of sucking pests throughout the crop growth period. Such conditions need protection against sucking pests compared to Non-*Bt* era. Hence, knowledge on effect of different nitrogen doses on sucking pests and yield under unprotected and protected conditions in *Bt* cotton is needed. Keeping this in view, field studies were conducted at RARS, Lam, Guntur to evaluate the impact of nitrogen on incidence of sucking insect pests in BG II cotton.

2. Materials and Methods

2.1 Layout and Treatments: Field experiment was conducted at Regional Agricultural Research Station, Lam, Guntur during *Kharif* 2013 in a randomised block design with eight treatments of different nitrogen levels *i.e.* 120, 150, 180, 225, 280, 350, 440 & 0 kg N ha^{-1} and each replicated thrice. The crop was sown in the month of August and distance between rows and plants was 105 cm and 45 cm respectively; crop received nitrogen in three splits at 30 DAS, 60 DAS and 90 DAS.

The crop was maintained under unprotected and protected conditions. In unprotected condition, the crop was grown without any insecticidal sprays while, in protected condition the crop was protected against insect pests by giving insecticidal sprays as per the ANGRAU recommendations.

The insecticides were sprayed on crop; the first spraying with fipronil 5% SC @ 40 g a.i. ha^{-1} was imposed at 48 DAS to manage the leafhopper population. Second spray with acephate 75% SP @ 750 g a.i. ha^{-1} was imposed at 97 DAS against aphid and leafhopper population in all the treatments.

2.2 Observations: Sucking insect pest incidence was recorded from top, middle and bottom leaves, on five randomly selected plants in each plot at weekly interval starting from three weeks after sowing. The average of all the five observations was calculated and expressed as mean population. The data pertaining to the population of pests was subjected to square root transformation from respective treatments. The seed cotton yield from each plot was recorded twice separately and per hectare yield was deduced. Percent yield loss was also calculated. Correlation was calculated between nitrogen levels and mean pest population; also between nitrogen levels and yield. Analysis of variance was done with the transformed data by using AGRISTAT statistical package.

3. Results

3.1 Influence of Nitrogen on aphid

It was evident from the data that more aphid incidence levels were observed at high nitrogen doses compared to without application and recommended dose of nitrogen (0 kg N ha^{-1} and 120 kg N ha^{-1}) both under unprotected and protected conditions.

The mean aphid population was increased from 14.12 per three leaves to 42.54 per three leaves as nitrogen doses increased from 0 kg ha^{-1} to 440 kg ha^{-1} (Table 1) and there was a significant positive correlation between mean aphid population and nitrogen treatments ($r = 0.82$, $P<0.05$) (Figs. 1) under unprotected conditions. Similarly, in protected conditions, mean aphid population increased from 9.67 per three leaves to 26.20 per three leaves with increase in nitrogen doses from 0 kg ha^{-1} to 440 kg ha^{-1} (Table 1) and there was a significant positive correlation between mean aphid population and nitrogen treatments ($r = 0.93$, $P<0.05$) (Figs. 3) but, there is reduction of population in protected condition than in unprotected condition.

A study reported that aphid density in cotton plants fertilized with 72 kg ha^{-1} N (84.2±22.7 aphids / plant) was significantly higher than fertilized with 0 and 108 kg ha^{-1} N (36.7±4.0 and 47.8±18.7 aphids / plant)[4], similarly another study also reported that significantly more aphids were found on plants fertilized with 375 ppm N (230.50 ± 78.07) than on plants fertilized with 0, 19 and 38 ppm N (9.54 ± 2.62, 20.08 ± 5.58 and 62.83 ± 29.07 respectively) [5].

3.2 Influence of Nitrogen on Leaf hopper

It was evident from the data that more leafhopper incidence levels were observed at high nitrogen doses compared to the without nitrogen treatment. The mean leafhopper population increased from 3.54 per three leaves to 6.52 per three leaves under unprotected conditions and 2.51 per three leaves to 4.99 per three leaves as nitrogen dose increased from 0 kg ha^{-1} to 440 kg ha^{-1} (Table 1) and significant positive correlation between mean leafhopper population and nitrogen treatments ($r = 0.70, 0.84$ $P<0.05$) was observed both under unprotected and protected conditions (Figs. 2, 4) but, there is reduction of population in protected condition than in unprotected condition.

These results are in conformity with a study that the maximum dose of nitrogen 200 kg ha^{-1} resulted in higher mean of 0.44 leafhoppers per leaf as compared to minimum dose of 50 kg N ha^{-1} recorded 0.22 leafhoppers per leaf [3] and also the application of 120 kg N ha^{-1} and 160 kg N ha^{-1} recorded lower leafhopper population over incremental level of 200 kg N ha^{-1} [6].

3.3 Influence of Nitrogen on Yield of Bt cotton

3.3.1 Unprotected conditions

The perusal of the data presented in the table 2 indicated that seed cotton yield ranged from 1440 kg ha^{-1} to 1967 kg ha^{-1}. Lowest seed cotton yield of 1440 kg ha^{-1} was recorded in the 0 kg N ha^{-1} treatment. The highest seed cotton yield of 1967 kg ha^{-1} was recorded in 150 kg N ha^{-1} applied treatment and it was on a par with other nitrogen treatments 120 to 440 kg ha^{-1}.

The highest increase in seed cotton yield of 7.2% was observed in 150 kg N ha^{-1} (1967 kg ha^{-1}) over recommended dose of 120 kg N ha^{-1} (1826 kg ha^{-1}). The lowest seed cotton yield of 1440 kg ha^{-1} was recorded in without nitrogen applied treatment, which was 26.8% lower than the seed cotton yield recorded in recommended dose of fertilizer. Other treatments *viz*., 180 kg N ha^{-1}, 225 kg N ha^{-1}, 280 kg N ha^{-1}, 350 kg N ha^{-1} and 440 kg N ha^{-1} recorded the seed cotton yield of 1848 kg ha^{-1}, 1874 kg ha^{-1}, 1785 kg ha^{-1}, 1774 kg ha^{-1} and 1904 kg ha^{-1} and were 1.2%, 2.6%, - 2.3%, - 2.9% and 4.1% over recommended dose of nitrogen respectively.

Though highest seed cotton yield was recorded in 150 kg N ha^{-1} applied treatment, thereafter decrease in seed cotton yield was noticed with increase in nitrogen dose. A study reported that application of 25 per cent more than Recommended Dose of Fertilizer (RDF) *i.e.* 150 kg N ha^{-1} produced higher seed cotton yield (3374 kg ha^{-1}) than 50 per cent more than RDF *i.e.* 180 kg N ha^{-1} (3080 kg ha^{-1}) but it was on a par with RDF *i.e.* 120 N kg ha^{-1} (3365 kg ha^{-1}) [7].

3.3.2 Protected conditions

Perusal of the data presented in the table 2 showed that in protected condition also similar trend was observed. The highest seed cotton yield of 2272 kg ha^{-1} was recorded in the treatment applied with 150 kg N ha^{-1}. Although the increased application of 150 kg N ha^{-1} produced the higher mean seed cotton yields, it was on a par with other treatments 120 to 440 kg N ha^{-1}. The lowest seed cotton yield of 1591 kg ha^{-1} was recorded in without nitrogen applied treatment *i.e.* 0 kg N ha^{-1}.

The highest increase in seed cotton yield of 8.6% was observed in 150 kg N ha^{-1} (2272 kg ha^{-1}) over recommended dose of 120 kg N ha^{-1} (2076 kg ha^{-1}). The lowest seed cotton yield of 1591 kg ha^{-1} was recorded in without nitrogen applied treatment, which was 30.4% lower than the seed cotton yield recorded in recommended dose of nitrogen fertilizer. Other treatments *viz*., 180 kg N ha^{-1}, 225 kg N ha^{-1}, 280 kg N ha^{-1}, 350 kg N ha^{-1} and 440 kg N ha^{-1} recorded the seed cotton yield of 2065 kg ha^{-1}, 2042 kg ha^{-1}, 2053 kg ha^{-1}, 2043 kg ha^{-1} and 2048 kg ha^{-1} and were -0.5%, - 1.6%, - 1.1%, - 1.6% and – 1.3% over recommended dose of nitrogen respectively.

Non-significant positive correlation was observed between seed cotton yield and nitrogen treatments under both unprotected and protected conditions (r = 0.32, 0.32; *P*<0.05) (Figs. 5, 6).

There is an increase in yield in protected than in unprotected conditions (Figs.7), may be due to management of insect pests. These results are in conformity with a work revealing that the seed cotton yield obtained from sprayed plots was significantly higher compared to unsprayed plots. The yield was 16.24, 12.32, 12.80, 17.16, 11.84, 12.28, 20.80, 16 q ha^{-1} under protected conditions where as under unprotected conditions, it was 10.48 q ha^{-1} [8].

3.3.3 Cost Benefit Ratio

Cost-benefit ratios of different treatments were calculated for both protected and unprotected trials (Table 2). Under unprotected conditions, the highest cost-benefit ratio of 1:1.45 was recorded in 150 kg N ha^{-1} applied treatment. Under protected conditions, the highest ratio of 1: 1.61 was recorded in 150 kg N ha^{-1} applied treatment.

Table 1: Influence of Nitrogen doses on sucking pests and yield in Jaadu BG-II cotton hybrid

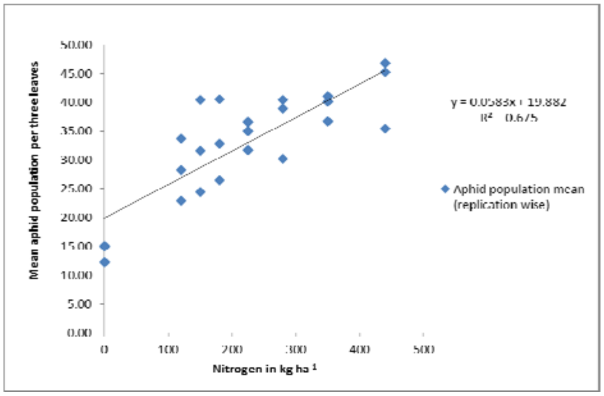
	Unprotected			**Protected**		
Treatment kg N ha^{-1}	**Aphids/three leaves**	**leafhoppers / three leaves**	**Yield (kg ha^{-1})**	**Aphids/three leaves**	**leafhoppers / three leaves**	**Yield (kg ha^{-1})**
T_1 : 120 (Recommended)	28.32 (5.42) ^{b}	4.74 (2.40) ^{ab}	1826 ^{b}	13.47 (3.80) ^{b}	3.48 (2.12) ^{b}	2076 ^{b}
T_2 : 150	32.19 (5.76) ^{bc}	5.17 (2.48) ^{bc}	1967 ^{b}	15.25 (4.03)^{b}	3.73 (2.17) ^{bc}	2272 ^{b}
T_3 : 180	33.29 (5.86) ^{c}	5.55 (2.56) ^{bc}	1848 ^{b}	15.71 (4.09)^{b}	3.98 (2.23) ^{bcd}	2065^{b}
T_4 : 225	34.47 (5.96) ^{cd}	5.76 (2.60) ^{bc}	1874 ^{b}	17.04 (4.25)^{bc}	4.21 (2.28) ^{bcde}	2042 ^{b}
T_5 : 280	36.56 (6.13) ^{cd}	5.86 (2.62) ^{bc}	1785 ^{b}	20.62 (4.65)^{cd}	4.48 (2.34) ^{cde}	2053 ^{b}
T_6 : 350	39.33 (6.35) ^{de}	6.16 (2.68) ^{bc}	1774 ^{b}	21.92 (4.79)^{d}	4.74 (2.40) ^{de}	2043 ^{b}
T_7 : 440	42.54 (6.60) ^{e}	6.52 (2.74) ^{c}	1904 ^{b}	26.20 (5.22)^{e}	4.99 (2.45) ^{e}	2048 ^{b}
T_8 : 0	14.12 (3.89) ^{a}	3.54 (2.13) ^{a}	1440 ^{a}	9.67 (3.27)^{a}	2.51 (1.87) ^{a}	1591 ^{a}
CD (P=0.05)	0.38	0.31	282.13	0.48	0.20	345.66
CV%	3.81	7.02	8.94	6.40	5.19	9.75
Correlation (r) (*P*<0.05)	0.82	0.70	0.32 (NS)	0.93	0.84	0.32 (NS)

Figures in parentheses are $\sqrt{x+1}$ values. Numbers with same superscript are not statistically different

NS- Non-significant

Table 2: Influence of nitrogen levels on seed cotton yield under unprotected and protected conditions

	Unprotected			**Protected**			**Yield difference between protected and unprotected (kg ha^{-1})**	**Per cent increase in yield under protected over unprotected**
Treatment	**Yield (kg ha^{-1})**	**Per cent increased yield over recommended dose of fertilizer**	**Cost-Benifit Ratio**	**Yield (kg ha^{-1})**	**Per cent increased yield over recommended dose of fertilizer**	**Cost-Benifit Ratio**		
T_1 : 120 kg N ha^{-1} (Recommended)	1826 ^{b}		1 : 1.35	2076 ^{b}		1 : 1.48	250	
T_2 : 150 kg N ha^{-1}	1967 ^{b}	7.2	1 : 1.45	2272 ^{b}	8.6	1 : 1.61	304	17.9
T_3 : 180 kg N ha^{-1}	1848 ^{b}	1.2	1 : 1.35	2065^{b}	- 0.5	1 : 1.45	216	- 15.7
T_4 : 225 kg N ha^{-1}	1874 ^{b}	2.6	1 : 1.36	2042 ^{b}	- 1.6	1 : 1.42	168	- 49.1
T_5 : 280 kg N ha^{-1}	1785 ^{b}	- 2.3	1 : 1.28	2053 ^{b}	- 1.1	1 : 1.42	268	6.7
T_6 : 350 kg N ha^{-1}	1774 ^{b}	- 2.9	1 : 1.25	2043 ^{b}	- 1.6	1 : 1.39	269	7.0
T_7 : 440 kg N ha^{-1}	1904 ^{b}	4.1	1 : 1.32	2048 ^{b}	- 1.3	1 : 1.37	144	- 73.7
T_8 : 0 kg N ha^{-1}	1440 ^{a}	- 26.8	1 : 1.09	1591 ^{a}	- 30.4	1 : 1.16	151	- 65.7
CD (P=0.05)	282.13			345.66				
CV%	8.94			9.75				



Figs 1: Effect of nitrogen on mean population of aphid in *Bt* cotton hybrid Jaadu (unprotected)

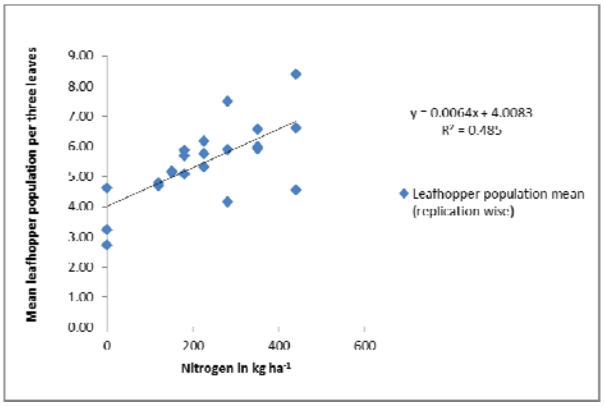


Fig 2: Effect of nitrogen on mean population of leafhopper in *Bt* cotton hybrid Jaadu (unprotected)

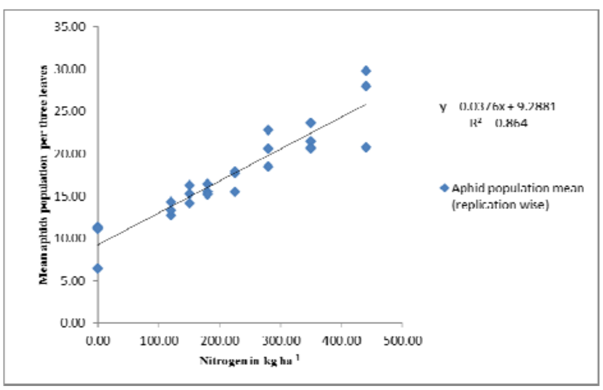


Fig 3: Effect of nitrogen on mean population of aphid in *Bt* cotton hybrid Jaadu (protected)

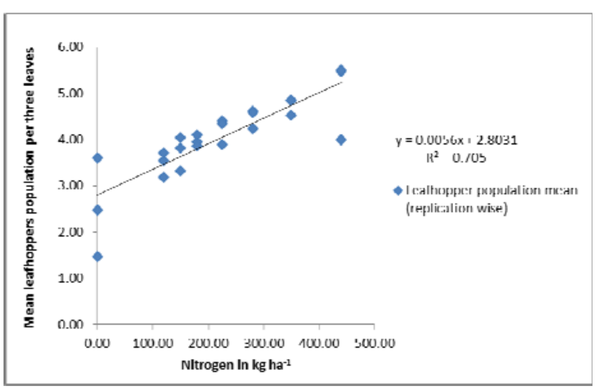


Fig 4: Effect of nitrogen on mean population of leafhopper in *Bt* cotton hybrid Jaadu (protected)

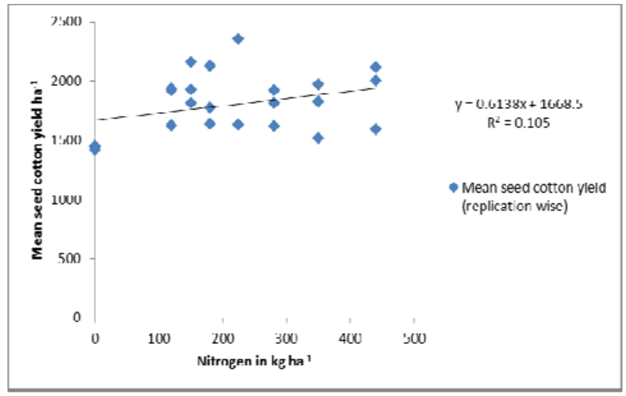


Fig 5: Effect of nitrogen on mean seed cotton yield in *Bt* cotton hybrid Jaadu (unprotected)

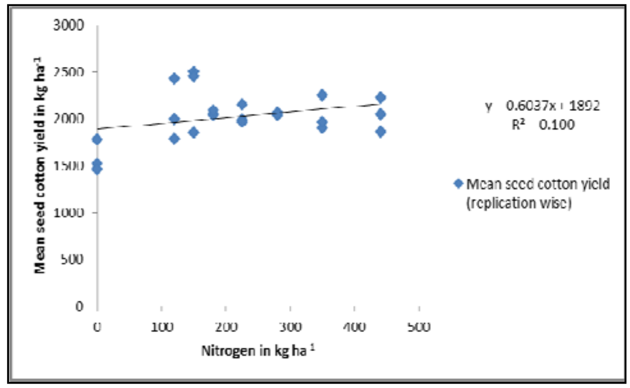


Fig 6: Effect of nitrogen on mean seed cotton yield in *Bt* cotton hybrid Jaadu (Protected)

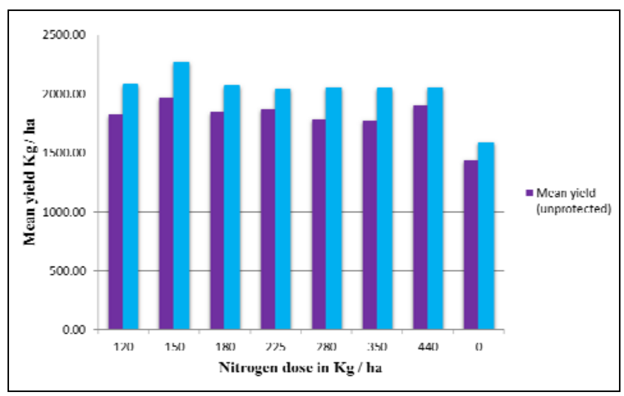


Fig 7: Influence of nitrogen levels on seed cotton hybrid yield under unprotected and protected conditions

4. Discussion

Higher populations of sucking pests in plots receiving higher nitrogen doses is due to more vigorous growth of plants which are generally more palatable for herbivores than plants that exhibit slow growth. Nitrogen fertilization increase rates of new leaf flushing in indeterminate plants and affect leaf development rates. Many folivores typically prefer new leaf tissues because of their relatively high N content and low toughness, and changes in flushing phenology can substantially affect interactions between plants and insect herbivores.

The increased seed cotton yields obtained at 150 kg N ha^{-1} and decreasing trend was observed from 150 to 440 kg N ha^{-1} in both protected and unprotected conditions was mainly due to, with excessive nitrogen application, cotton plants may put forwarding excessive vegetative growth thus imbalancing between source to sink and at higher nitrogen fertiliser rates, the soil and crop retain a smaller proportion of the nitrogen applied and a greater proportion is lost from the system through denitrification and leaching. If there is a high level of native nitrogen in the soil, cotton crops make limited use of nitrogen fertiliser, especially when applied at high rates. A study reported that, at 400 kg N ha^{-1}fertiliser applied, only 128 kg N ha^{-1} (32% of the 400 kg N ha^{-1}) are recovered by the crop. Soil has a finite capacity to retain fertiliser nitrogen and when this is exceeded, nitrogen is lost from the soil–plant system (42% of the 400 kg N ha^{-1} applied) [9] and favourable weather conditions prevailed during *Kharif* 2013 at RARS, Lam, Guntur resulted in the development of aphids, leafhoppers and other sucking pests at higher dose of nitrogen application. Further, management of aphid, leafhopper and other sucking pests under protected conditions also played a role in enhanced seed cotton yields over unsprayed conditions.

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